REPORT DOCUMENTATION PAGE

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6. AUTHOR(S) Sean Washburn	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Dept Physics and Astronomy, Univ North Carolina at Chapel Hill Chapel Hill, NC 27599-3255	8. PERFORMING ORGANIZATION REPORT NUMBER
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11. SUPPLEMENTARY NOTES

The views, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy or decision, unless so designated by other documentation.

12 a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution unlimited.	12 b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

The project to study quantum transport in Si/SiGe heterostructures has, in addition to attacking the proposed goals, emphasized work on the two-dimensional metal-insulator transition. Ballistic Aharonov-Bohm devices were made and studied. The experimental results on the metal-insulator complement and sharply contrast with the results from much lower mobility systems like Si-MOSFETs. Data can be scaled according to an equation drawn from considerations of zero-temperature quantum critical points, but with a much larger conductivity (by a factor of nearly 100) than in the more generic (lower) mobility samples.

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(Continuation Sheet)

The specific original goal was an attempt to fabricate and study quantum wires and to use them to attack four problems in quantum transport:
(1) study of ballistic transport in point contacts,
(2) study Aharonov-Bohm interference in loops,
(3) begin studies of Luttinger correlations in one-dimensional transport and
(4) study of electrostatic effects in quantum interference.

The first two of these targets were accomplished, and the results are published two refereed articles:

``Observation of ballistic conductance and Aharonov-Bohm Oscillations in Si/SiGe heterostructures," *Applied Physics Letters*, **6** (1994) pp 3114-6, WX Gao, K Ismail, KY Lee, JO Chu and S Washburn;

``Fabrication of Aharonov-Bohm rings in Si/SiGe heterostructures," *Microelectronic Engineering*, **2** (1995) pp 79-82, KY Lee, K Ismail, JO Chu, WX Gao and S Washburn.

In these experiments small wires (widths down to 0.2μm) were wet or reactive ion etched into the cap and dopant layers of a high-mobility heterostructure. Schottky gates were then deposited across parts of the channel or over the entire device to permit carrier concentration in the conducting channels to be modulated. Balllistic channel widths down to less than \$0.3 \mu m\$ could be formed in this fashion. A back-gated permitted carrier concentration control in the entire device. Some details of the research have been given in previous annual reports as well.

The third target was also covered in the same experiments, but with no dramatic revelations about the correlated motion of the carriers. Hence no separate publications were submitted as the results did not warrant dissemination. Some of the results have been mentioned as illustrative data in publications such as:

``Some consequences of chaos for quantum devices," in *Quantum Based Electronic Devices and Systems*, ed: MA Stroscio and M Dutta (World Scientific, Singapore, 1998); Int J High Speed Electron Syst, 9, 209-22 (1998). S Washburn.

``Resource Letter QIMS-1: Quantum Interference in Macroscopic Samples," *Am J Phys*, **63**, 683--93 (1995). (invited) S Das Sarma, T Kawamura and S Washburn.

The fourth target consumed much of the time. It was discovered during the course of the grant that the moderately high-mobility two dimensional electron or hole systems are behaving as if the carriers undergo a transition from the insulating behavior expected for non-interacting carriers (where conductivity decreases with decreasing temperature) to a metallic "state" where the opposite trend appears. This appears to be an extension of granular systems in which a superconductor-insulator transition has been studied since the late 1980's. The following publications contain the results from these experiments.

``Metal-Insulator Transition in Two Dimensions: Effects of Disorder and Magnetic Field," *Phys Rev Lett*, **79**, 1543-6 (1997). D Popovic, A Fowler and S Washburn.

Comment on ``Electric Field Scaling at B=0 Metal-Insulator Transition in Two Dimensions," cond-mat/9707061. K Ismail, JO Chu, D Popovic, A Fowler and S Washburn.

``Conductance Fluctuations Near the Two-Dimensional Metal-Insulator Transition," Int. Conf. Electronic Properties of Two-Dimensional Systems, *Physica* B, **249-251**, 504-7 (1998). KP Li, D Popovic and S Washburn.

``Metal-Insulator Transition in a low-mobility two-dimensional electron gas," Int. Conf. Electronic Properties of Two-Dimensional Systems, *Physica B*, **249-251**, 701-4 (1998). D Popovic, AB Fowler and S Washburn.

``Absence of Localization in Certain Field Effect Transistors," *Superlattices and Microstructures*, **23**, 581-91 (1998). (invited) S Washburn, D Popovic, KP Li and AB Fowler.

``Scaling and universal behavior near the two-dimensional metal-insulator transition" Proc. 22nd Int School Theoretical Physics, Ustron, 10-15 Sept 1998; *Mol Phys Rept*, **24**, 150-7 (1999). (invited) S Washburn, NJ Kim, KP Li and D Popovic.

In addition to the publications, the grant supported the final year of PhD training for WX Gao (now employed at SGS-Thomson), and the first two years of the training for NJ Kim (accepted a postdoc at Case Western Reserve) who will defend his dissertation later this month. It also provided partial support for travel to conferences and contributed talks by the students once each year as well as partial support for the PI to deliver invited lectures at NC State University, University of Cincinnati, University of Virginia and the 22nd International School of Theoretical Physics.

Enclosure 2

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CONTRACT/GRANT NUMBER: 33036-EL

REPORT TITLE: QuantumTransport in Si/SiGe Nanostructures

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SUBMITTED FOR PUBLICATION TO (applicable only if report is manuscript):

Sincerely,

Enclosure 3

FORECAST EXPENDITURE REPORT

(IMPORTANT!>>>YOU MUST REPLY TO RECEIVE ADDITIONAL FUNDING<<<)

The research agreement identified below is under consideration for additional funding. The contemplated funding, resulting in an extension to the performance period of the agreement, is consistent with the terms and conditions of the agreement. Before a decision can be made to provide the additional funding, the following information is needed: (i) an accounting of costs incurred to date and (ii) a projection of financial needs for the period of the agreement extension. Please complete SECTION 2, below **within 30 days of receipt of this request** and return to: U.S. Army Research Office, ATTN: (Name provided by ARO) P.O. Box 12211, Research Triangle Park, North Carolina, 27709-2211.

SECTION 1: GENERAL INFORMATION

ARO Proposal Number: (Provided by ARO)
Agreement Number: (Provided by ARO)
Agreement Period: (Provided by ARO) Fom To(provided by ARO)
Recipient: (Provided by ARO)
Principal Investigator: (Provided by ARO)

Award Amount: ($ provided by ARO)
Funded Amount: ($ provided by ARO)
Period Funded Through (Provided by ARO)
Planned Funding: (Provided by ARO)

Planned Period of Extension for: (No of Mos.) months beginning (Provided by ARO)
ARO Technical Monitor: (Provided by ARO) **Monitor's Phone #:** (Provided by ARO)
ARO Technical Monitor's E-mail: (Provided by ARO)

SECTION 2: ACCOUNTING AND FORECASTING OR EXPENDITURES

Payments to Date: $ (Provided by ARO)

1. Expenditures (cost incurrances from date of contract/grant initiation) as of date of receipt of this request or as of most recent cutt-off in accounting records: $ 90000
2. Additional projected expenditures before (date entered by ARO) $______
3. Total of items 1 and 2: $______
4. Forecast expenditures for the proposed (number) months period of extension: $______*

* The forecast cannot exceed the planned level of funding identified in SECTION 1. If the forecast expenditures differ significantly from the budget previously negotiated and included in the research agreement, a new budget must be submitted. A "significantly different" budget is defined as (i) a decrease in the planned funding level cited above or (ii) a deviation of 10% (plus or minus) to any cost element (direct labor, indirect expense, travel, etc.) included in the budget.

Date: 6 July 01

Signature [signature]
Principal Investigator

SECTION 3: FOR U.S. ARMY RESEARCH OFFICE USE ONLY

____Recommend funding at level cited in SECTION 1, above.

____Recommend no additional funds be provided at this time.

____Recommend funding consistent with revised budget of Principal Investigator.

____Recommend extension of agreement through________without additional funds.

____Recommend funding in amount of $________

____Other (Explanation attached).

Date:____________

Signature____________
Technical Monitor